Step 10. Total Panel Output

Follow the procedure for slab-on-grade construction, Step 10, substituting heat flow downward (q_d) for the apportioned downward and edgewise heat flow (q_{de}).

Step 11. Fluid Circuit

Follow the procedure for slab-on-grade construction, Step 11.

Step 12. Boiler Size

Follow the procedure for slab-on-grade construction, Step 12.

Installation Details, Accessories and Controls

The design of the two-pipe, direct return forced circulation system which is used in a panel heating system is described generally in Chapter 21 Hot Water Heating Systems. In addition to the usual valves, a balancing valve should be installed in the supply or return connection of each panel in order to permit the heat output of the panel to be balanced with other panels in the same zone.

While all piping should be designed to minimize trapping of air or water, few panel heating systems can be installed to be completely free of air traps. For that reason, panel heating systems cannot usually be filled by flooding nor drained by gravity alone. The system can be filled and the air removed if the system is flushed with a sufficient flow of water. To empty the system a flow of compressed gas is used to assist gravity drainage of the water. Provisions for both flushing and blowing should be included in the piping. Devices for the collection and venting of the gases that will appear during operation should also be provided.

The control of panel heating systems is discussed in Chapter 38 Automatic Control.

Warm Air Panels

The first three steps in the design of warm air panels are the same as those outlined for warm water panels and the same performance curves can be used. The balance of the design can be determined from the data in the Chapter on Forced Warm Air Systems and Manual 7-A of the *National Warm Air Heating and Air Conditioning Association.*

Electric Panels

Electric panel heating systems can be designed by using part of the procedure for warm water panels as a guide. See also Chapter 41 Electric Heating.

Step 1. Heat Loss

Follow the procedure for warm water panels, Step 1.

Step 2. Required Panel Output

Follow the procedure for warm water panels, Step 2.

Step 3. Panel Surface Temperature

Follow the procedure for warm water panels, Step 3.

Step 4. Panel Heat Loss

Determine the heat loss from the panel, using the panel surface temperature found in Step 3 and the factors in Chapter 9 Heat Transmission Coefficients of Building Materials.

Step 5. Panel Rating

Select a panel which has a rating at least equal to the required panel output, plus the panel heat loss (3413 Btu = 1 kilowatt hour). If the selected panel has a rating that is appreciably higher than the required panel output plus the panel loss, the panel heat loss should be redetermined (Steps 3 and 4).

If the required panel output plus the panel heat loss is greater than the ratings of available panels, a larger panel should be used, the heat loss of the room should be reduced, and in addition or alternately supplementary heating should be provided.

Step 6. Installation and Wiring

See Chapter 41 Electric Heating and manufacturers recommendations and instructions.

SNOW MELTING

The practicability of melting snow by means of heated coils has been demonstrated in a large number of installations in sidewalks, roadways, ramps, and runways. In addition to eliminating the need for snow removal, other advantages gained are greater safety to pedestrians and vehicles, and reduction of labor in removal of slush from floors.

The design of a snow-melting system involves primarily (1) a determination of the heat requirement which depends on snow fall and atmospheric conditions, (2) the coil and piping design which depends on heat transfer from a panel and on friction loss in piping due to the circulating medium used, and (3) the selection or design of a heat exchanger for heating the circulating medium.

DESIGN

Heating Requirements

The heating requirements for snow melting are affected by four atmospheric factors: (1) rate of snowfall, (2) air temperature, (3) wind velocity, and (4) humidity. The effects of these factors can be evaluated by consideration of the action of snow falling on a warmed surface.

The first flakes fall on a dry, warm surface, and are then warmed to 32 F and melted. The water from the melted snow soon forms a film over the entire area and starts to evaporate. The evaporation of the film is a *mass* transfer from the surface to the atmosphere. In addition, there is a *heat* transfer from the film to the ambient air and surfaces.

Both the mass and heat transfers attain a maximum only when the film is entirely free of snow. Theoretically this is impossible because some time will elapse while the snow is warmed to 32 F. For all practical purposes, however, it is permissible to assume the snow to be melted as fast as it falls so that the surface may be considered entirely free of snow. The ratio of free area to total area is known as the *free area ratio*, R_A. When $R_A = 1$, there is no snow on the surface and the mass and heat transfers are at a maximum. When $R_A = 0$, the snow covers the entire area and there is no mass or heat transfer.

Research on the insulating effects of snow indicate that there are just three practical values for the free area ratio, R_A; they are 1, 0.5, and 0. A general rule to follow is that emergency areas should be designed with $A_r = 1$; commercial areas (e.g., sidewalks around stores, etc.) may be designed with $R_A = 0.5$; and private driveways, or areas where low installation costs are imperative, may be designed with $R_A = 0$. For a more